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Improved Esophageal Fistula Closure Devices for Cattle and Sheep

ABSTRACT

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This publication describes a redesigned esophageal fistula plug and an esophageal cannula. These closure devices set forth state-of-the-art structural design, are more rugged, require minimal time to construct, and are relatively light when compared with previous esophageal fistula closure devices. In addition, the redesigned fistula closure devices are reliable in use and easily adapted to animal necks of various depths. The design of the fistula plug for use in cattle and sheep, along with the design for an esophageal cannula for use in cattle, are discussed, and fabrication plans are included.

KEYWORDS: Cannulas, esophageal fistula, livestock diets, plugs

ACKNOWLEDGMENTS

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IMPROVED ESOPHAGEAL FISTULA CLOSURE DEVICES FOR CATTLE AND SHEEP

by D.M. Anderson, D.L. Mertz, W.E. Franklin, and P.J. Manz[1]

INTRODUCTION

Esophageal fistulas provide animal scientists a tool for sampling the botanical and chemical composition of an animal's diet. During periods when diets are not being collected, it is essential that the esophageal fistula be closed in order to ensure that near normal biological functions continue within the animal. Therefore, functional closure devices, that is, plugs and cannulas are necessary research tools.

Since Torrel's (1954) classic paper describing the practical use of the esophageal fistula in range animal nutrition research, two types of closure devices, the plug and the cannula, have been developed. A plug serves to close the fistula during periods when the animal's diet is not being sampled. When diets are to be sampled, the entire plug must be removed from the esophagus leaving only the open fistula through which food boluses are diverted from the esophagus and out through the animal's neck for collection. When the cap of a cannula is in place, it too serves as a plug. However, upon removal of the cap, the cannula can be left in place when collecting a diet because the cannula provides a fixed diameter tube through which the food boluses pass from the esophagus and out through the animal's neck for collection. Inplace cannulas with removable caps have been designed for use with domestic animals (Taylor and Bryant 1977) and wildlife (Veteto and others 1972), but Theurer and others (1976) reported that open fistulas are probably preferable to cannulated fistulas for obtaining representative diets. Several types of fistula plugs and cannulas have been developed for use in esophageally fistulated animals (Van Dyne and Torell 1964, Harris and others 1967, Alder 1969, Little and Takken 1970, Breen and Hunter 1976, Ellis and others 1984). Lack of detailed fabrication plans in previous publications and functional improvements in existing closure devices (Van Dyne and Torell 1964, Taylor and Bryant 1977) led to the development of the esophageal closure devices described in this paper.

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For those researchers without the facilities to make their own closure devices, the Physical Science Laboratory at New Mexico State University, P.O. Box 3548, Las Cruces, NM 88003 is willing to build both plugs and cannulas at cost. Researchers may also get blueprints from the same source. Write to the above address for more information.

AN ESOPHAGEAL PLUG

The esophageal fistula plug used for cattle and sheep (figs. 1-6) consists of three parts: a spoon with a hinged and threaded rod (fig. 3, cattle; fig. 4 sheep), the plug (fig. 5 cattle; fig. 6 sheep), and a wingnut to hold the plug securely to the spoon once the device is properly inserted into the esophageal fistula. The only difference in a closure device of this type for use in cattle vs. sheep is size, as indicated by the dimensions of the three parts (table 1).

The spoon is constructed from aluminum tubing, with stainless steel threaded rod and wingnut. The plug is machined from an acetal resin and has a slick, tough surface and a constant weight. The acetal resin bar stock is machined into a closed cone-shaped tube that provides a recessed area for the wingnut (figs. 1 and 2). Once the equipment is set to machine plugs, 10 plugs can be fabricated in an hour. An earlier design of the fistula spoon had the threaded rod hinged on a 1/8-inch-diameter aluminum rod, bent into a C-shape and welded to the spoon. In the new plug design (figs. 3 and 4), an aluminum clevis is welded to the spoon. With more than twice the surface area for welding, plus greater weld penetration into both the spoon and the base of the clevis, a more substantial hinge is obtained. It is desirable to offset the hinge slightly past the halfway point from one end of the spoon. Removing the plug from the esophagus and rotating the spoon 180°, when required, changes the pressure points inside the esophagus, further reducing the risk of pressure necrosis caused by the weight of the spoon.

Close the open lumen of an esophageal fistula with an esophageal plug by inserting the spoon into the fistula with the threaded rod flat against the surface of the spoon. Once the spoon is inside the esophagus, position the threaded rod through the lumen of the fistula at a 90° angle to the spoon. Slip the plug over the rod and use the wingnut to secure the spoon to the plug.

We use aluminum and stainless steel to prevent corrosion resulting from the moist environment of the esophagus. Based on the density of aluminum and stainless steel, similar size spoons made of stainless steel alone would weigh about three times more than spoons constructed of aluminum. To reduce the incidence of pressure necrosis caused by cannulas or plugs in the esophagus, lightweight durable closure devices are preferable in esophageally fistulated animals.

The cast-resin plug portion of earlier esophageal plugs has disadvantages. Cast-resin plugs require molds of several lengths and diameters. Plugs are individually molded from a resin and catalyst mixture that has a shelf life of only 6 months. Each plug requires about 1 hour to cure. Even with careful handling, about 30 percent of the plugs are unsuitable because of excess porosity causing a pitted surface or breakage during removal from the aluminum mold. Acetal resin plugs can be machined to any diameter and length depending on the length of the bar stock used and the lathe setting. Longer plugs can be manufactured to accommodate individual animal variability for the depth of the esophagus in the animal's neck. A hole is bored in the base of the acetal resin plug to fit the clevis. Tapering this larger hole makes coupling the plug to the spoon easier. Because the wingnut does not protrude beyond the rim of the plug, it is protected from being rubbed loose by the animal. This recessed area also prevents moisture from accumulating on the threaded rod. Long plugs can be machined with a deeper recessed area, and spoons with standard-length threaded rods can be used regardless of the depth of the esophagus in the animal's neck.

The esophageal fistula plugs described in this paper are more rugged and require about 20 percent less time to construct than previous designs, provide for a recessed area to protect the wingnut that holds the plug to the spoon, and have a consistent weight. These plugs are designed to be used with the esophageal fistula dilator (Anderson and Mertz 1982), if excessively small esoph-

ageal fistulas need to be enlarged before the plug is inserted.

AN ESOPHAGEAL CANNULA

The esophageal cannula (figs. 7-11) likewise consists of three parts: a spoon with a flanged opening (fig. 8), a barrel (fig. 10), and a plug/stem/cap assembly (fig. 11) for closing the barrel once the cannula is properly inserted into an esophageal fistula. The spoon is constructed from 1-5/8-inch-diameter schedule-40-polyvinyl-chloride (PVC) plumbing pipe. The barrel and plug/stem/cap assembly are fabricated from aluminum stock (figs. 10,11).

To make two spoons, one four-way slip connecter and one inline PVC slip connecter, also 1-5/8 inches in diameter, are required. A pair of opposite openings in the four-way slip connecter and both ends of the inline slip connecter are machined as shown in fig. 8. The inline slip connecter is then cut into two tubular pieces; one is two-thirds the length of the other. These two pieces are glued into the machined openings in the four-way slip connecter. The hole, at a 90° angle to the extended tube, has now been offset again so the spoon can be rotated 180°, if needed, to change the pressure points inside the esophagus. The spoon is now ready to be fabricated by sawing the four-way slip connecter into two halves and grinding each half to the proper shape without leaving rough edges (fig. 9).

Before closing a fistula with a cannula, first practice attaching the barrel to the spoon before inserting it into the animal (fig. 7). To facilitate this procedure during actual assembly inside the animal's esophagus, make waterproof marks on the inside of the barrel and spoon to correspond with one pair of the four evenly spaced reverse L-shaped slots (fig. 10) that have been machined into the base of the barrel and corresponding tabs that extend into the opening of the spoon. Look through the barrel and align these two pairs of marks. Hold the spoon rigid with one hand and with the other hand push the barrel into the flange that has been machined into the base of the spoon opening (fig. 8) until the barrel is seated, then turn the barrel clockwise until resistance indicates assembly has taken place. Compression of the O-ring at the base of the barrel (fig. 7) ensures a secure locking bayonet attachment between the spoon and the barrel once they are assembled. To prevent swallowing of the cannula spoon, tie the two ends of a sturdy string together after passing one end of the string through the open spoon and barrel. The string not only prevents the animal from swallowing the spoon before the barrel is attached, but it aids in helping align the opening in the spoon with the fistula. Guide the barrel toward the flanged opening while holding the string taut. Proceed as before in assembling the cannula. Once the spoon and barrel have been assembled inside the animal's esophagus, cut and remove the string. Screw the cap onto the exposed end of the barrel, and the procedure for closing an open fistula with a cannula is complete. The potential problem of aluminum galling can be prevented when the cap is screwed onto the barrel if the threads are first lubricated with a silicone-type grease. This ensures easy separation of the parts at a later date.

When removing the cannula, separate the barrel from the spoon. To prevent the animal from swallowing the spoon, insert a blunt rod through the barrel of the cannula, then reverse the steps taken for connecting the barrel to the spoon --turn the barrel counter-clockwise. Once the barrel is removed from the end

of the rod, work a string through the hole in the spoon and out between the spoon and wall of the esophagus. Holding on to the spoon with the string will ensure that it is not swallowed and can be positioned for removal from the esophagus.

Previous inplace cannula designs have used a threaded barrel that screwed into the spoon instead of using the bayonet connection described here (fig.10). Cross-threading was always a potential danger when using the earlier cannula design. The bayonet coupling has eliminated this problem. The butyl rubber O-ring located at the base of the barrel (fig. 7) ensures a secure fit between the spoon and barrel. To reduce cannula weight when in place, it was desirable to plug the opening into the barrel next to spoon, thus preventing diet from accumulating in the barrel, which would increase the weight of the cannula. The cattle cannula described in this paper weighs about 0.41 lb. This is about 2-1/2 times heavier than the esophageal plug (table 1). Obviously, cattle with esophagi that are deeper into the neck than average will require a cannula with a longer barrel and a longer plug and cap assembly.

The esophageal cannula described in this paper differs from previous designs in two major ways. First, a bayonet lock is used to secure the barrel to the spoon. This prevents the possibility of cross-threading the spoon during assembly of the barrel to the spoon. Second, closure of the cannula barrel next to the spoon, with the plug attached to the cap rather than to the barrel (Taylor and Bryant 1977), eliminates the need to change barrels when diets are to be collected.

Sheep cannulas of the type described in this paper have not been manufactued and field tested. But there do not appear to be any inherent problems in using 1-1/4-inch inside diameter PVC stock for the spoon with correspondingly smaller diameter barrels and plug/cap assemblies.

With both the fistula plug and cannula, a washer about 3-1/2 inches in diameter constructed from 1/8-inch thick plastic can be made and slipped over the cone-shaped acetal resin plug or aluminum barrel to prevent the closure device from being drawn into the fistula and swallowed. Because the cone-shaped plug and the cap assembly are larger in diameter than the aluminum barrel, the washer stays between the animal's neck and the end of the closure device.

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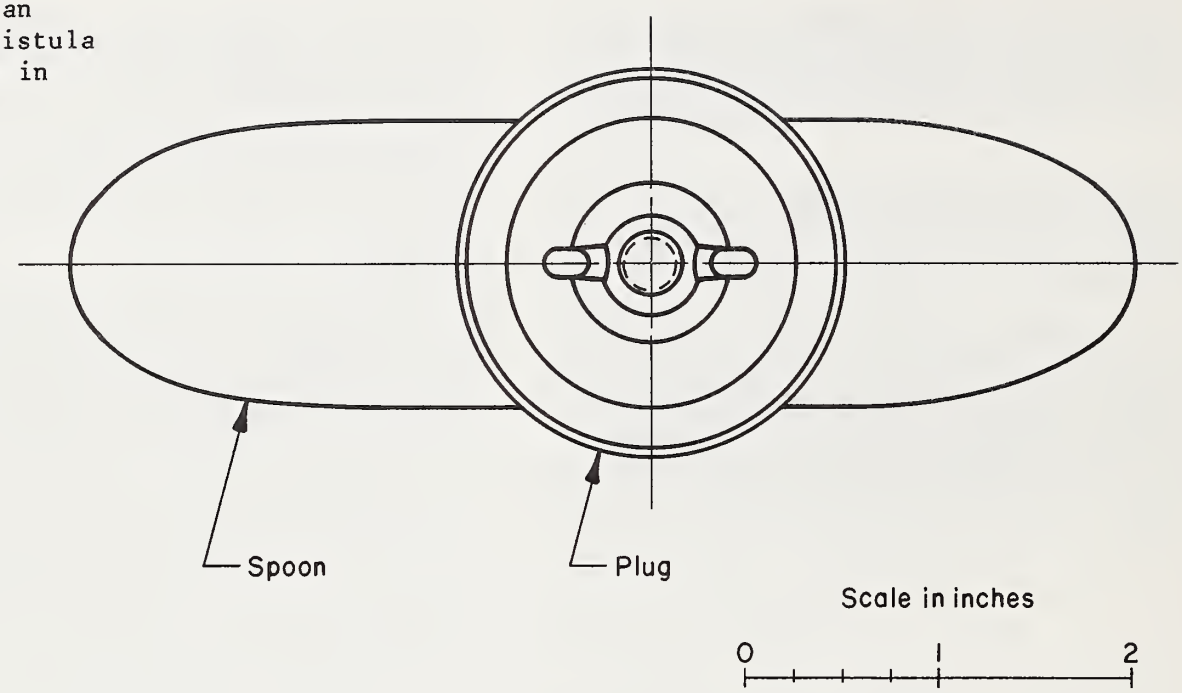
Table 1.--Dimensions and mass of cattle and sheep esophageal fistula plug parts

Plug part	Dimensions for			
	Cattle		Sheep	
	(in)	(lb)	(in)	(lb)
Spoon (aluminum):				
Weight	....	0.09	.....	0.07
Length	5.5	...	5.0	...
Tubing stock				
Outside diameter	2.0	...	1.25	...
Stainless steel threaded--				
Rod (diameter)	.25	...	.188	...
Clevis (diameter)	.5	...	.375	...
Plug (acetal resin):				
Weight	....	.08	.....	.04
Length	2.25	...	2.0	...
Total[1]	....	.17	.....	.12

[1] Mass of wingnut is negligible and therefore not included.

Figure 1.

Top and side view of spoon, plug, and stainless steel wingnut assembly portions of an esophageal fistula plug for use in cattle.



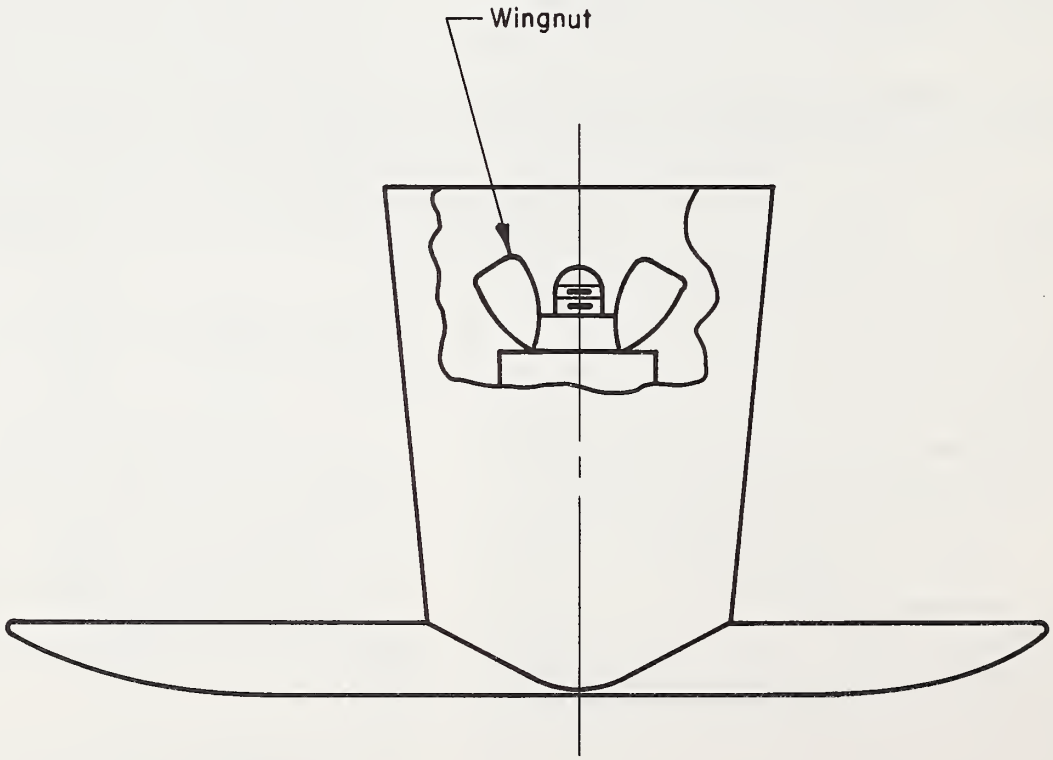
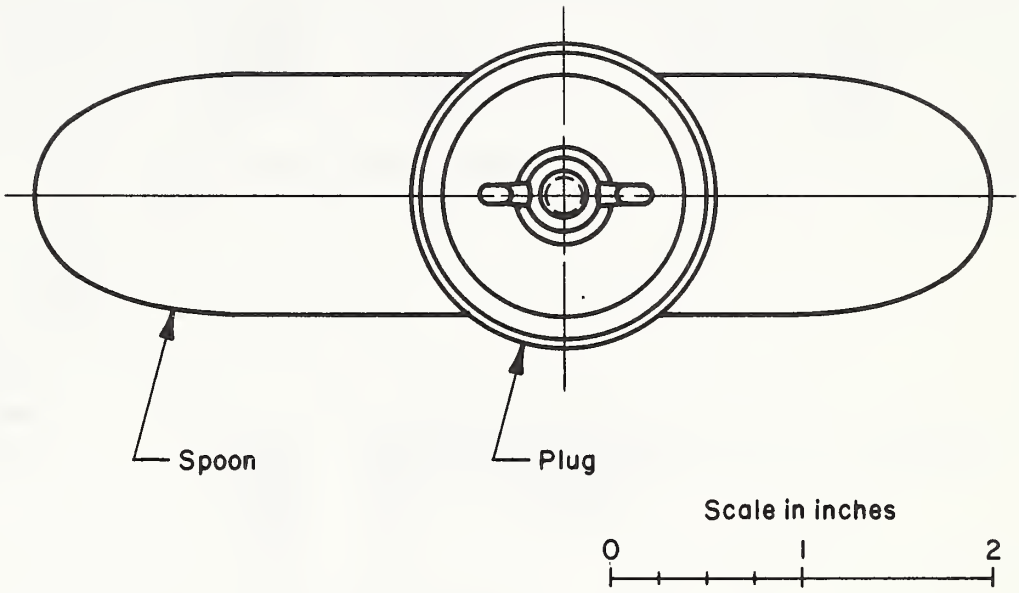


Figure 2.

Top and side view of spoon, plug, and stainless steel wingnut assembly portions of an esophageal fistula plug for use in sheep.



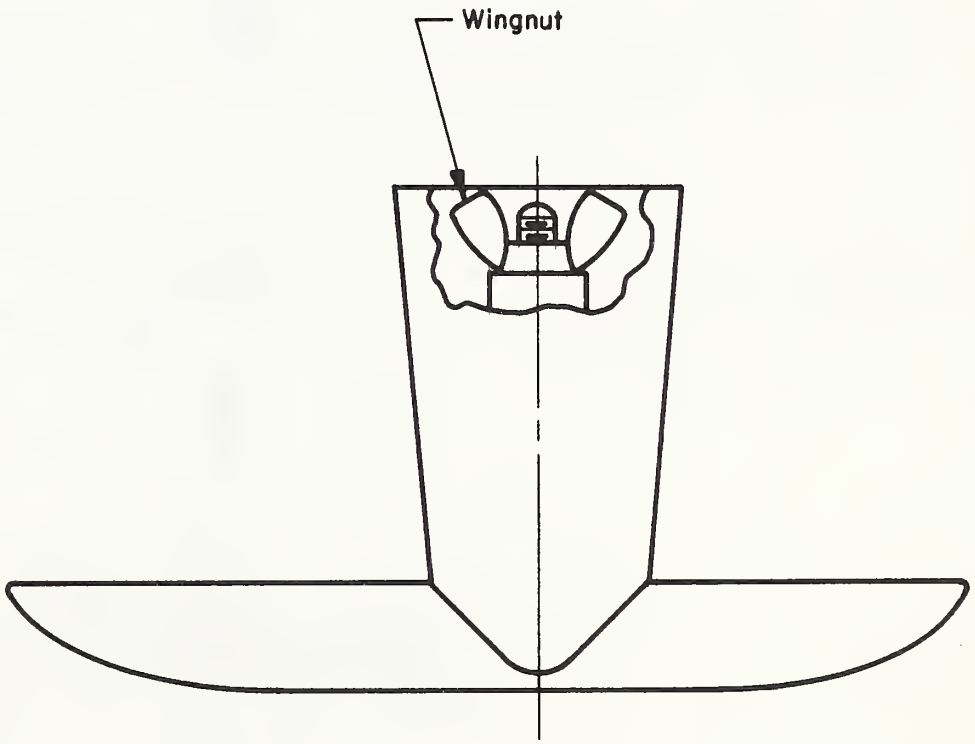


Figure 3

Top, side and end view of the aluminum spoon, the aluminum clevis, and the stainless steel rod portion of an esophageal fistula plug for use in cattle. Note all sharp edges should be removed.

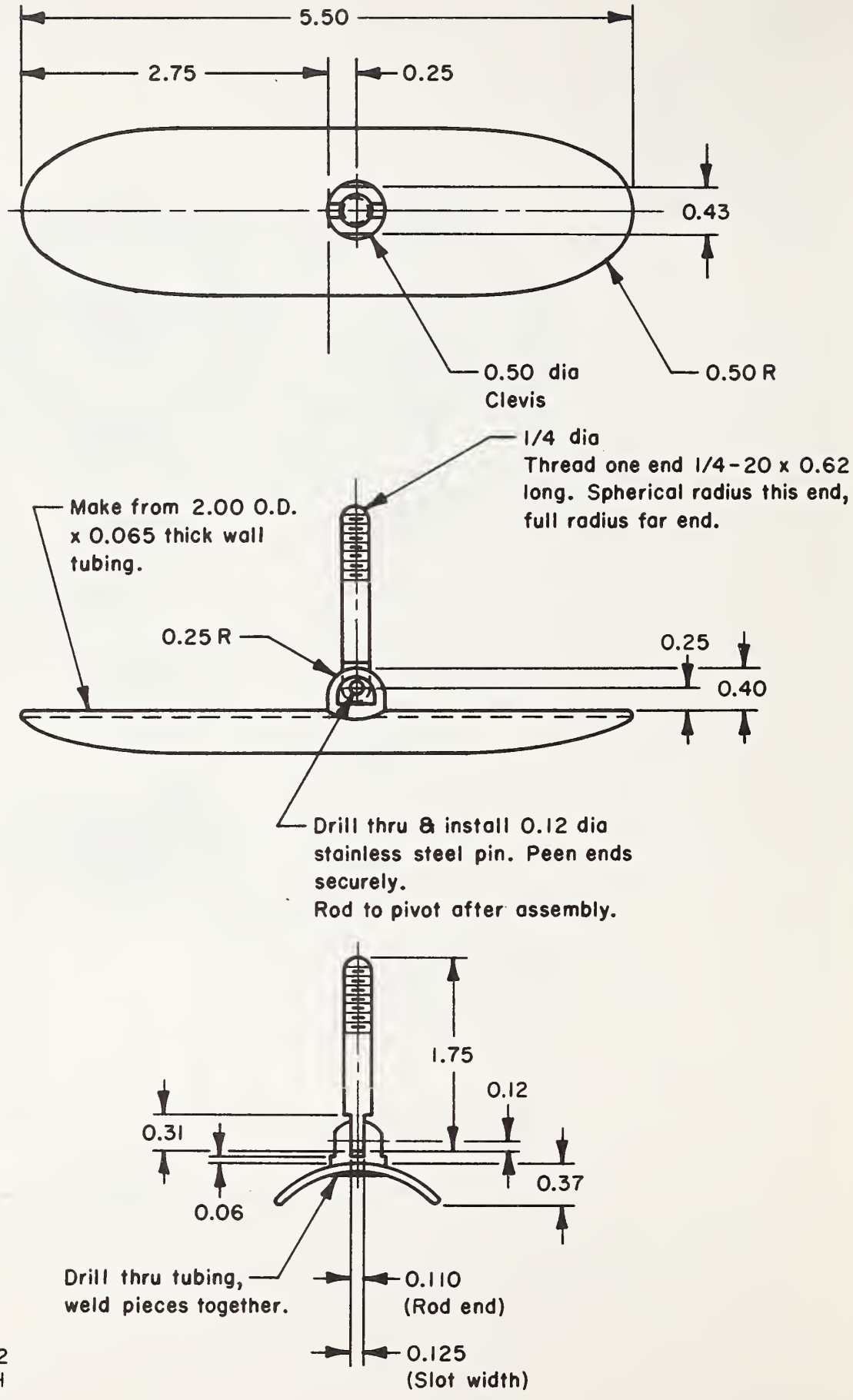


Figure 4.

Top, side, and end view of the aluminum spoon, the aluminum clevis, and the stainless steel rod portion of an esophageal fistula plug for use in sheep. Note all sharp edges should be removed.

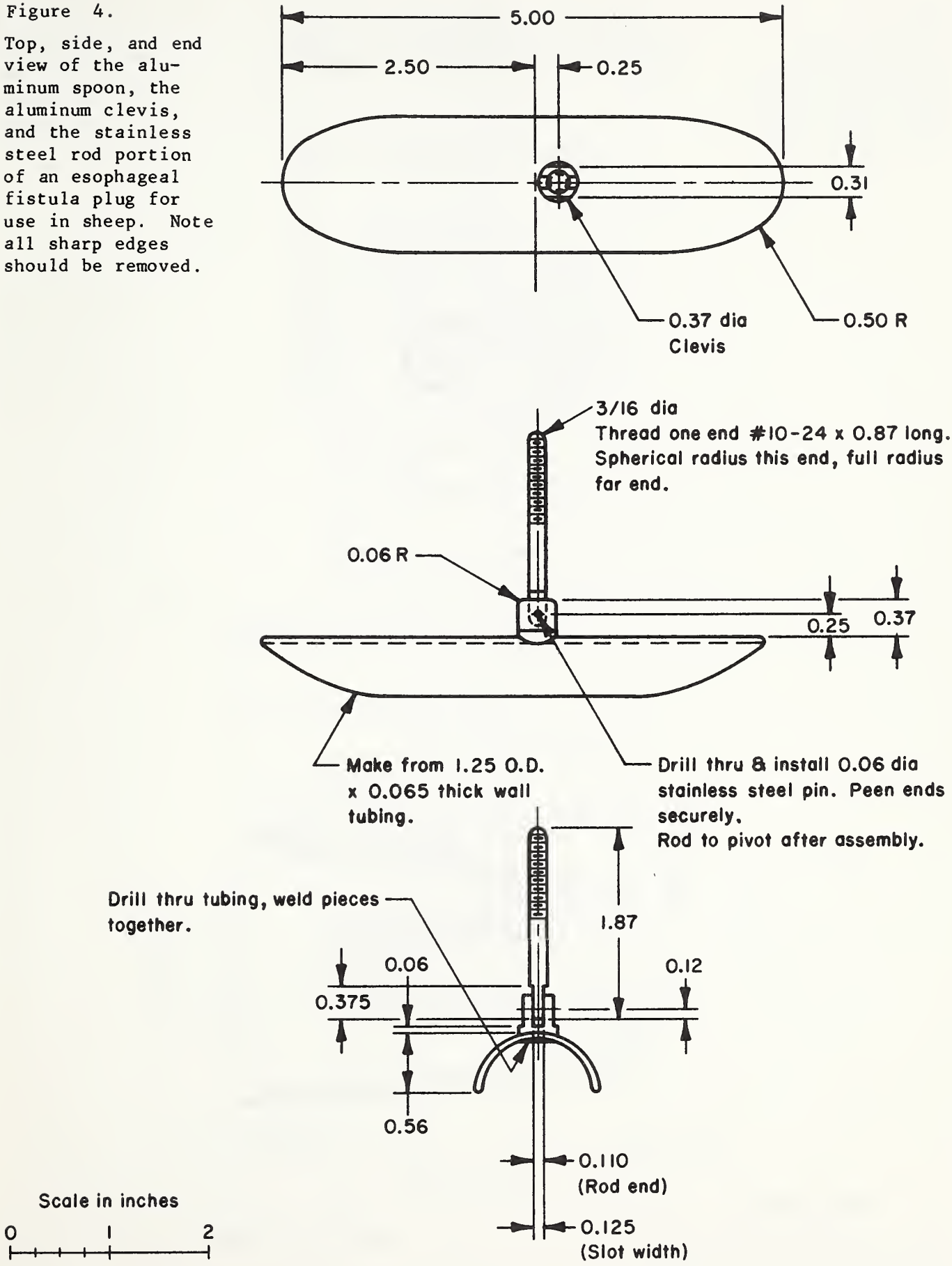


Figure 5.

Top and half-section view of an acetal resin esophageal fistula plug for use in cattle.

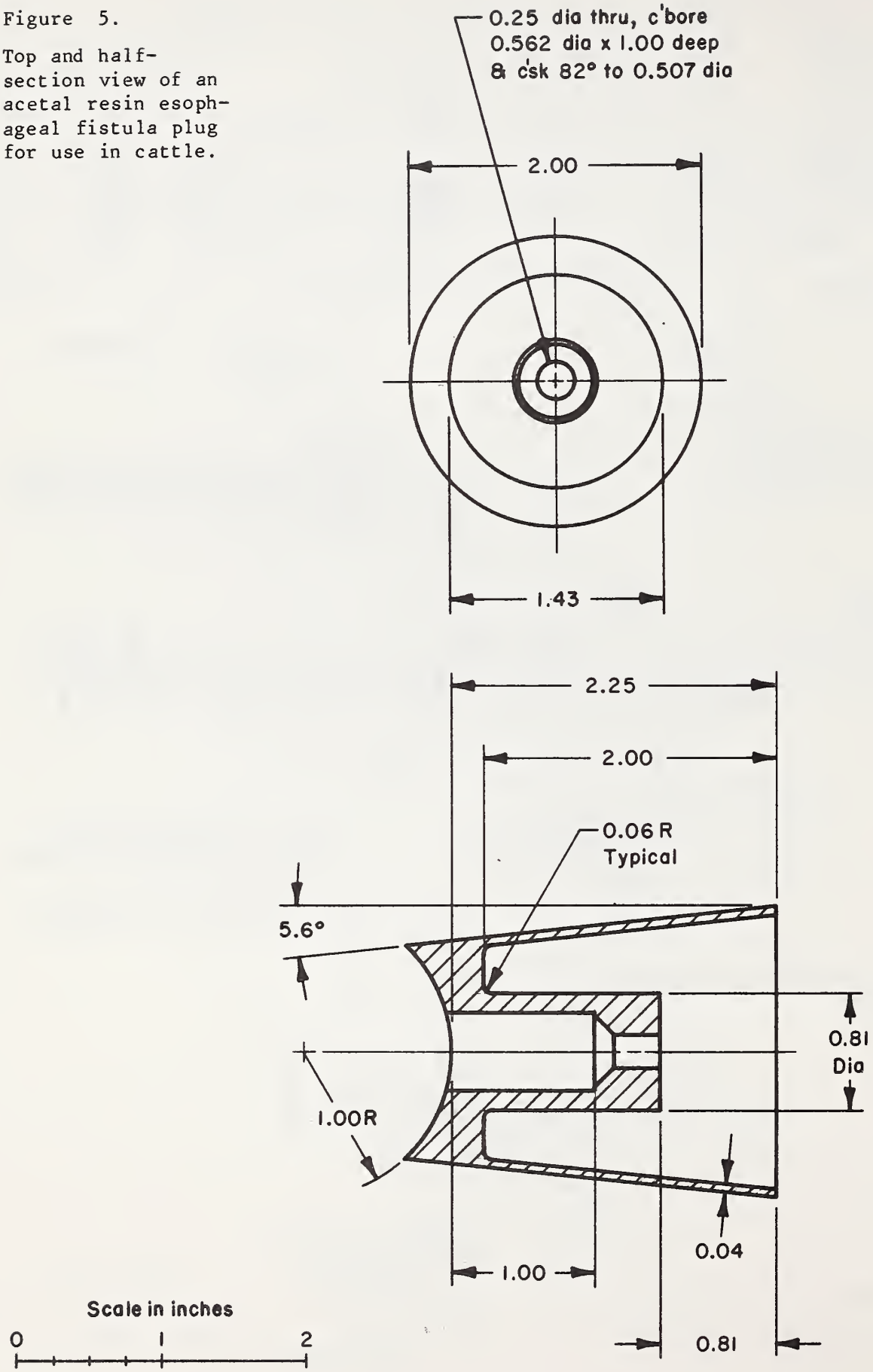


Figure 6.

Top and half-section view of an acetal resin esophageal fistula plug for use in sheep.

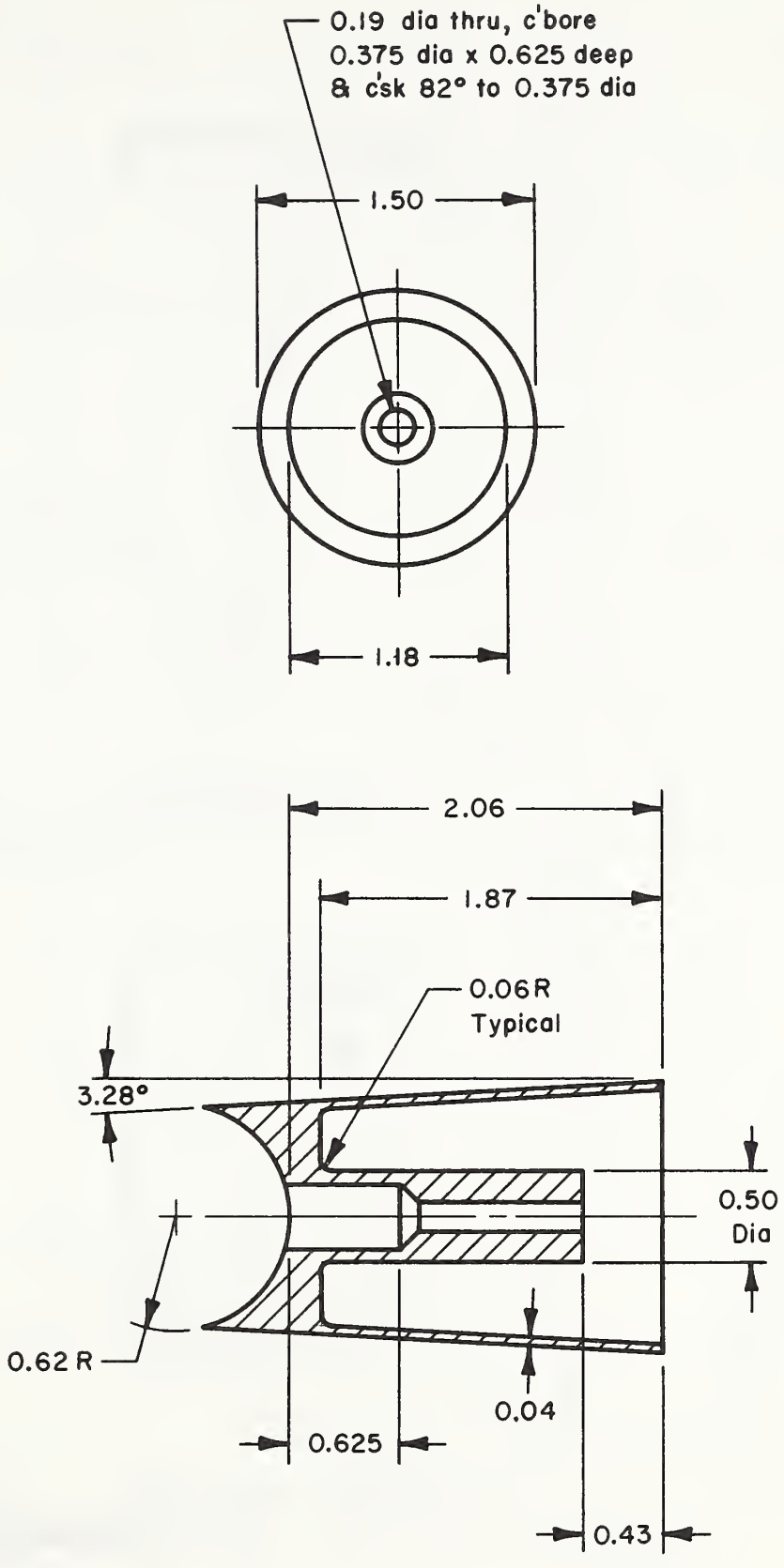


Figure 7. Side and half-section view of the polyvinyl-chloride spoon, aluminum barrel, and aluminum plug/stem/cap assembly portions of an esophageal cannula for use in cattle.

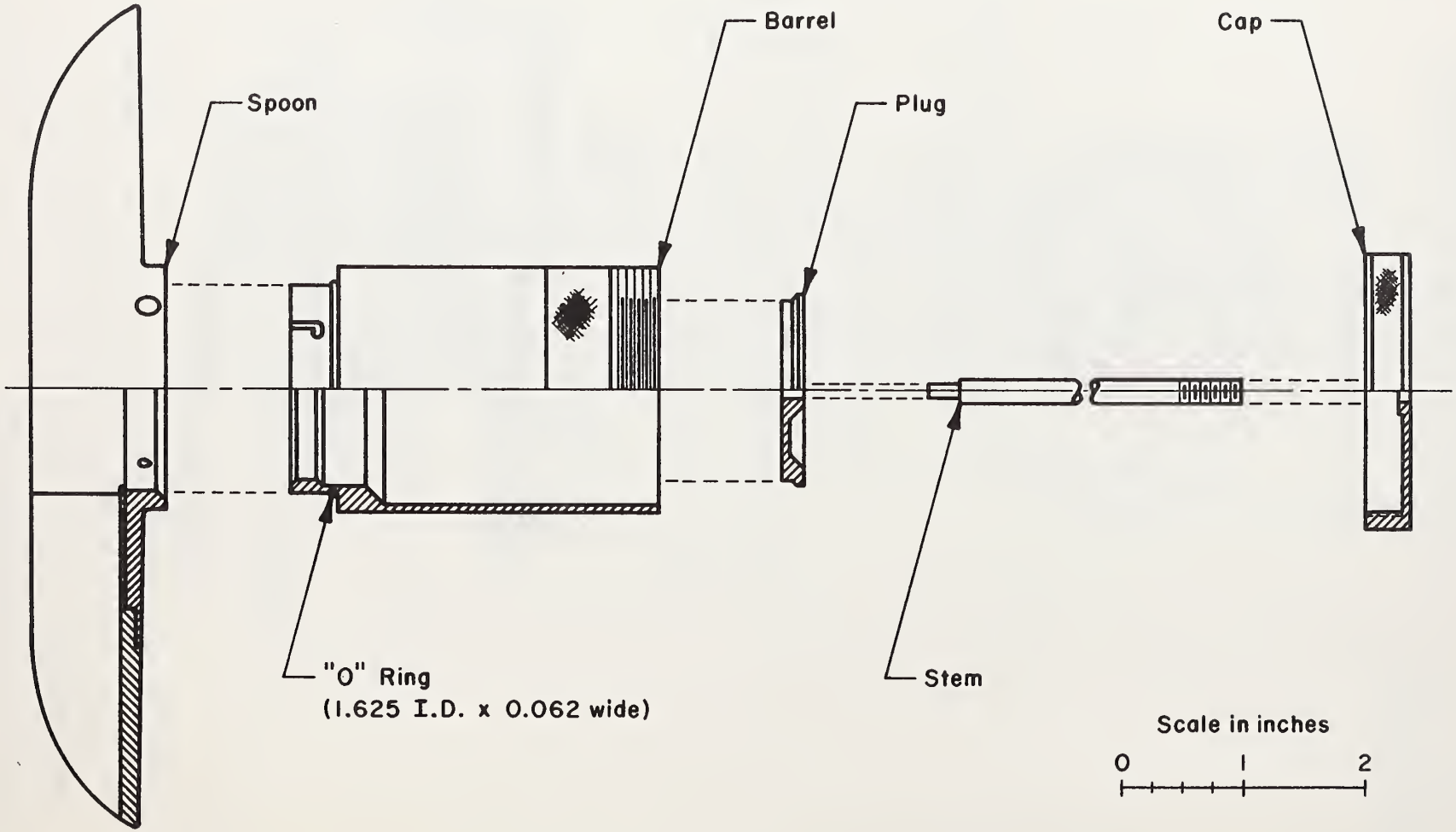


Figure 8.

Top and half-section view of the polyvinyl-chloride spoon portion of an esophageal cannula for use in cattle. Note all sharp edges should be removed.

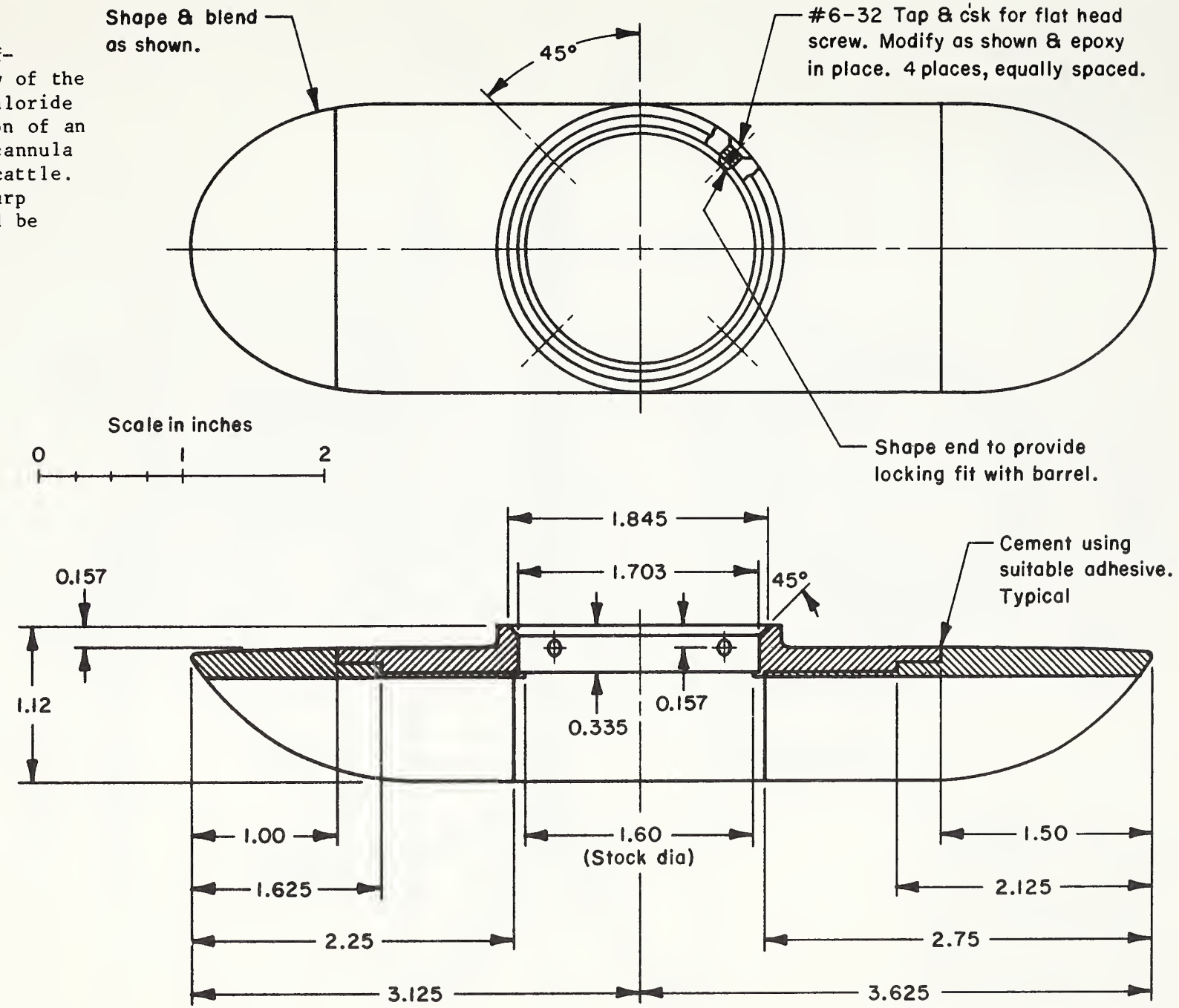


Figure 9.

Side view of 1-1/4 inch polyvinyl-chloride four-way slip connecter with inline slip connecters glued in place. Two cannula spoons will result from the saw cuts which are indicated as channels.

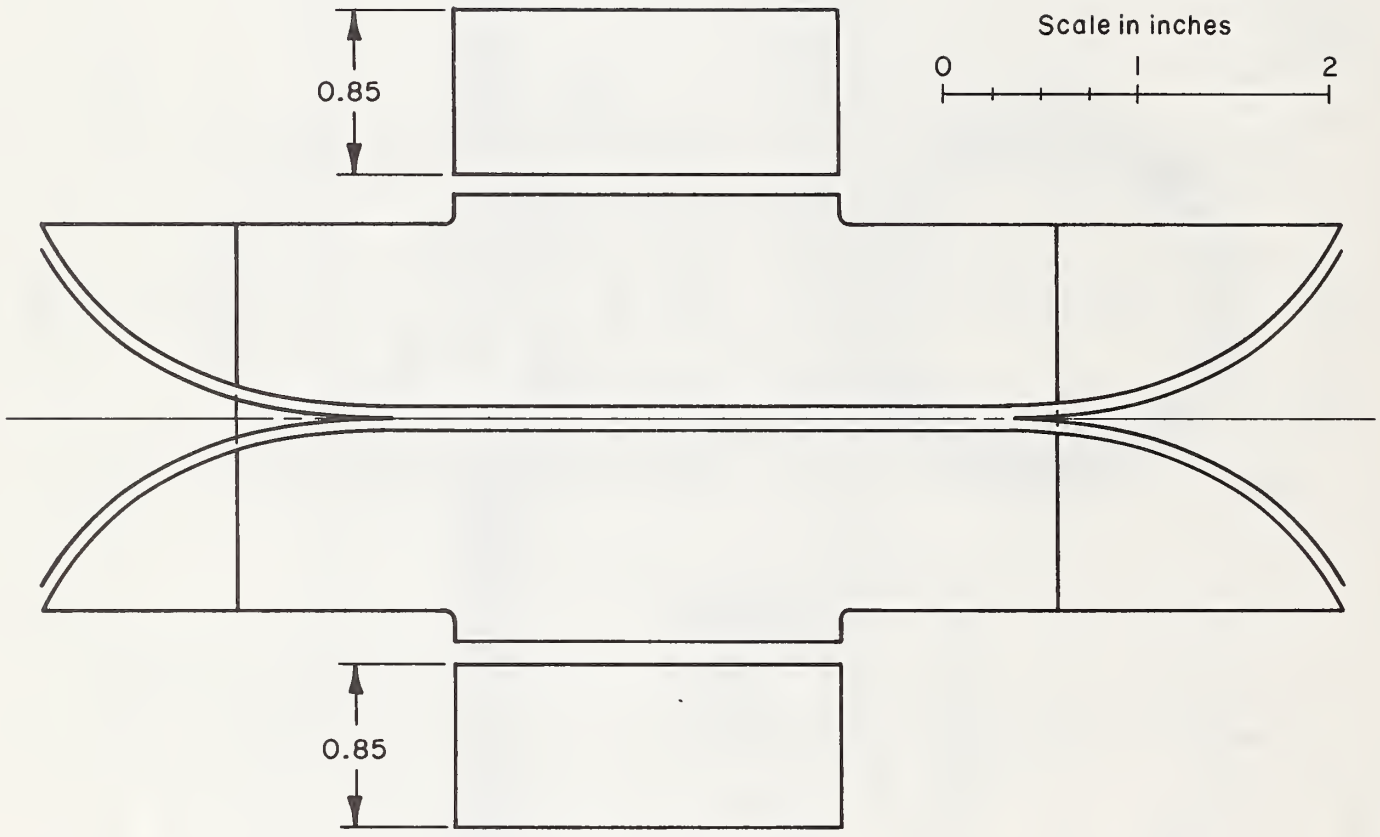


Figure 10.

Top and half-section view of the aluminum barrel portion of an esophageal cannula for use in cattle.

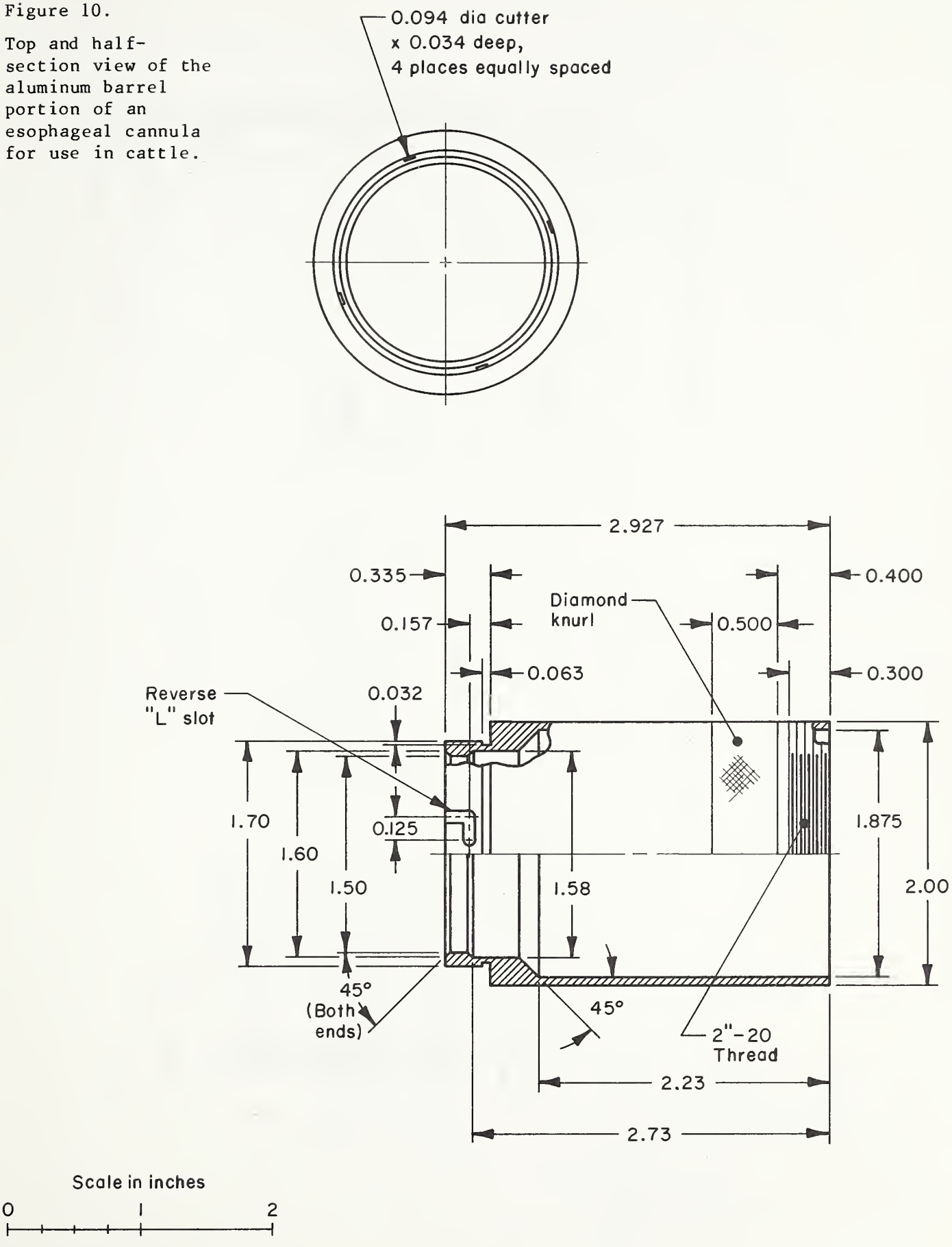
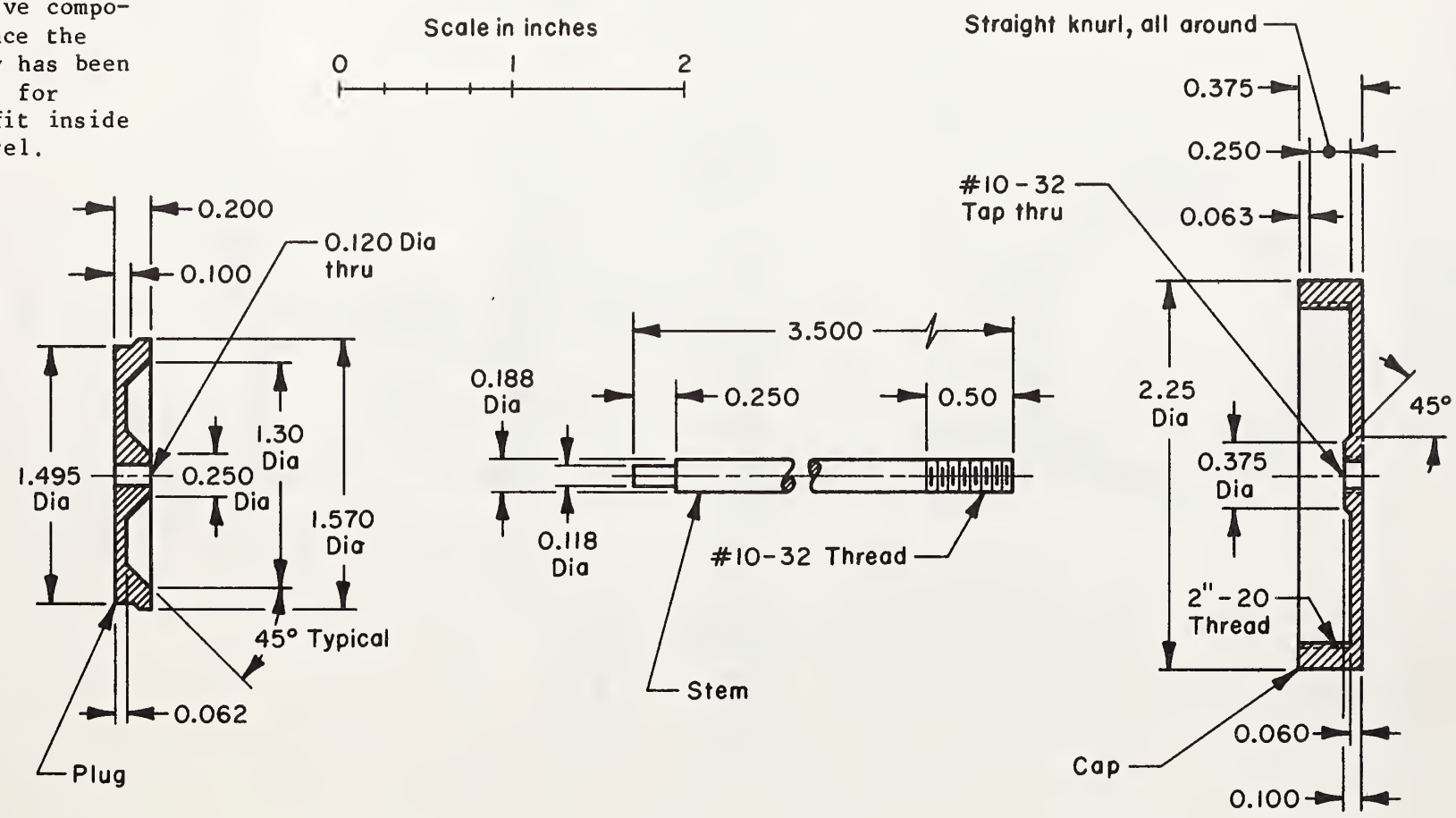


Figure 11.

Side and half-section view of the plug/stem/cap assembly portion of an esophageal cannula for use in cattle. Both ends of the stem should be welded to their respective components once the assembly has been adjusted for proper fit inside the barrel.



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